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TIN CONTAINING MINERALS OF THE PLATINUM GROUP IN COPPER AND NICKEL SULFIDE ORES

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Presented by Academy Member D. S. Belyankinyy, 7 July 1947

Considerable attention has been paid in recent years to the problem of the composition and structure of platinum minerals in copper and nickel sulfide ores. In conjunction with study of platinum minerals in ores themselves, tailings from alluvial deposits have been analyzed.

Since we had at our disposal a considerable quantity of metal from alluvial deposits and platinum tailings, obtained in the process of concentrating large quantities of copper and nickel sulfide ores, we decided to work out chemical and mineralogical analyses of the materials at hand. The objective of these analyses was to ascertain the identity of alluvial-deposit platinum minerals and concentrating-plant tailing minerals.

Together with this task a second was set forth. Namely, to define more accurately the composition of the main alluvial-deposit platinum minerals since information available in the literature on this problem proved inadequate. Even though, as a result of our study, the number of components determined might be far from complete. Also, chemical characteristics of individual crystals, unless their internal structure is taken into consideration, do not provide a satisfactory basis for considering the tested grains as being monomineral formations.

First of all, we had to define the method for chemical analysis of tailing material more accurately. After a series of systematic tests, it was found that deficiency in number of components was almost completely wiped out by the addition of tin, which had evaded notice in chemical

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analysis by escaping as volatile tetrachloride when solutions evaporated. This circumstance caused us to look still more attentively toward determining the composition of individual crystals. The fact that tin was found in the analyzed platinum minerals of tailings pointed to the need for carefully checking the analyses of platinum minerals from different deposits.

On the other hand, completed Academy mineralographical analyses of individual crystals taken from alluvial deposits and concentrating-plant tailings have shown that these crystals, in most cases, are not monomineral, but consist of two, three, and even four minerals.

The diagnostic characteristics of these minerals are not clearly defined under the microscope. Their physical and chemical properties change in accordance with changes in component composition. On the basis of analyses under the microscope, four varieties of individual minerals were distinguished. Their characteristics are given in Table 1.

Ferroplatinum is the most abundant mineral in tailings. It forms the main mass of magnetic, skeletal cubic crystals. Usually, it is closely associated with stannopalladinite, and less frequently with the indeterminate minerals No 1 and 2.

Table 1

Characteristics of Platinum Minerals From Alluvial Deposits and Concentrating Plant Tailings

Mineral	Color	Hardness	Acid Reaction			Crystal Structure
			HCl Conc	HNO_3 Conc	Aqua Regia	
Ferroplatinum	White with pinkish or yellowish tinge. Very lucid.	4-4.5 Very hard	--	--	--	Forms main mass of magnetic skeletal cubic and laminated crystals.
Indeterminate Mineral No 1	Slightly darker than ferroplatinum; distinctly grayish tinge.	Softer than ferroplatinum	-	--	--	In form of nonmagnetic cubic crystals
Copper Stanno-palladinite, Pd_3Sn_2	Darker than No 1; brownish or pinkish tinge	Same as previous mineral	--	-+[1]	++[2]	Forms main mass of of nonmagnetic rolled oblong crystals
Indeterminate Mineral No 2	Darkest; distinctly brownish tinge	Softer than stannopalladinite	-+[3]	++[4]	+++	In form of inclusions in magnetic and slightly magnetic cubic crystals

Key: -- no reaction; -+ slight reaction; ++ fast reaction; +++ instantaneous reaction.

1-brown sediment; 2-permanent brown sediment; 3-temporary brown color; 4-dissolves quickly, pitted brown surface forms.

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Under the microscope, minute stannopalladinite inclusions very often are found uniformly distributed through the whole mass of a crystal, although sometimes they are concentrated along the periphery, or in the form of long, coarse chains resembling an octahedron. Structural relationships prevailing among them, especially in the larger crystals, are such as are typical for decomposition products of solid solutions.

In addition to its occurrence as inclusions in ferroplatinum, stannopalladinite occurs in almost pure form as nonmagnetic, rolled, oblong cubic crystals. Frequently, such crystals have an outer skeleton of ferroplatinum.

Indeterminate mineral No 1 occurs in the form of individual, well-formed nonmagnetic cubic crystals. Quite frequently, it is observed in close association with stannopalladinite.

Indeterminate mineral No 2 usually occurs in association with stannopalladinite and ferroplatinum, often in the form of fine-grained graphic structures, and sometimes in the form of chains. Treating the surface of this mineral with a solution of HCl and $KClO_3$ reveals its granular structure.

Mineralographical analyses of platinum-mineral crystals have also shown the presence of sulfide inclusions (pyrrhotine, pentlandite, chalcopyrite, and others), magnetite, and ilmenite. Results of platinum-mineral grain analyses under the microscope have shown with considerable clarity that even well-formed crystals are not monomineral.

Therefore, conclusions drawn concerning the composition of individual minerals on the basis of a single chemical analysis without taking their internal structure into consideration could prove to be erroneous. Starting with this hypothesis in our work of determining the composition of platinum minerals, we subjected to chemical analysis only unit fractures in which there was a maximum concentration of a specific mineral. Representative results of such analyses are given in Table 2.

Table 2

Chemical Composition of Platinum Minerals (in Percent)

Chemical Components	Ferroplatinum	Indeterminate Mineral No 1	Stannopalladinite
Pt	77-81	51-63	15-20
Pd	0.8-1.3	12-20	40-45
Fe	11-13	0.6-0.9	0.3-2.3
Sn	up to 0.4	21-22	28-33
Cu	0.3-1.2	0.3-2.2	5-12
Ni	0.5-1.9	0.45	0.1-0.7
Insoluble Residue	0.5-1.7	1.0-2.3	0.25-2.5

As for indeterminate mineral No 2, its composition could not be determined due to lack of more or less pure crystals and grains in the analyzed material.

Thus, ferroplatinum was established with a satisfactory degree of

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[illegible] material from alluvial deposits, and in tailings which had been separated from copper and nickel sulfide ores. Increased palladium content is explained by the presence of small palladium-mineral inclusions. Stannopalladinite is a second clearly established mineral form. Considerable tin content and a uniform palladium to tin ratio in individual crystals, corresponding to the compound Pd_3Sn_2, provide the basis for considering this mineral copper stannopalladinite.

Indeterminate mineral No 1, represented by completely homogeneous, nonmagnetic cubic crystals, has a more complex composition. Apparently, in the given case, we have a solid solution of stannoplatinite and stannopalladinite.

In concentrating-plant tailings, which for the most part consist of the same minerals as alluvial-deposit tailings, ferroplatinum and copper stannopalladinite are the predominant platinum minerals. This was very definitely confirmed by graphic interpretation of the results of a great number of tailing analyses. If one were to combine the elements determined by chemical analysis and the results of mineralographic analysis into two groups, namely, Pt, Fe, Ni and Pd, Sn, Cu and, after adequate conversion, were to plot the results on two triangles, then the existence of two compositionally entirely different mineral forms would be clearly seen.

The new platinum minerals established in tailing material are structurally identical with the mineralographically established minerals of the original ores. Of course, they are only a small part of the platinum minerals contained in copper and nickel sulfide ores. As analyses of K. F. Beloglazov have shown, the main mass of platinum minerals, mainly palladium, in these ores are finely dispersed in the iron and nickel sulfides.

Nevertheless, there is no doubt that the detection of new and, up to this time, unknown platinum minerals poses new problems in regard to the mineralogy of copper and nickel sulfide ore deposits. Also, the question arises of arranging a number of special physical and chemical analyses, namely, a study of the solubility of platinum minerals in iron, copper, and nickel sulfide smelting, and a study of polycomponent systems: platinum-palladium-tin, and palladium-tin-copper.

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